Endovascular Treatment of Urgent Carotid Occlusion

Case selection & Technique

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Summary

Emergency revascularization of acute carotid artery occlusion is still controversial. We treated 15 patients (13 men and two women, mean age of 67.3 years) with acute atherosclerotic carotid occlusion by endovascular procedures and evaluated the usefulness of this treatment. All of the patients were evaluated with emergency MRI and MRA before treatment. Intracranial tandem arterial occlusion due to distal embolism was observed in nine patients, and contralateral carotid stenosis ($>70\%$) was observed in seven. The mean NIHSS score of the patients was 15.4 ± 7.4 (mean $\pm$ SD) before treatment. Treatment modality included local intraarterial fibrinolysis (LIF), percutaneous transluminal angioplasty (PTA), and carotid artery stenting (CAS). A protective balloon was successfully placed in the distal carotid artery through the plaque before recanalization in seven patients. Three patients were treated with LIF+PTA, five with PTA+CAS, six with LIF+PTA+CAS, and one with PTA only. Successful recanalization of the carotid artery was obtained in 14 of the 15 patients, and distal tandem middle cerebral artery occlusion was also successfully recanalized in eight of the nine patients. GOS was four or five in eight patients (good outcome group) and 1-3 in seven patients (poor outcome group). Mean NIHSS score of the 15 patients was (6.9 ± 7.4)

after treatment. Preoperative NIHSS score (10.3 ± 7.4) in the good outcome group was significantly lower than that (21.3 ± 5.4) in the poor outcome group.

The protective balloon technique, PTA with stenting, seems to be useful for acute revascularization of urgent carotid occlusion. Simultaneous treatment of the intracranial tandem occlusive lesion is essential to achieve good clinical results. Patients with acute carotid occlusion with NIHSS scores of less than 16 could be good candidates for this advanced treatment.

Introduction

Revascularization of acute complete occlusion of the cervical carotid artery is generally considered to have a poor prognosis or to be contraindicated because of time limitations, broad ischemic area, difficulty in identification of the extent of thrombus, intracranial tandem lesions, and possibility of distal embolization during the procedure¹. However, the various devices have been developed for the effective treatment of carotid artery occlusion, and these are anticipated to improve the prognosis of carotid artery occlusion.

We treated 15 cases with hyperacute cervical carotid artery occlusion by endovascular procedures using these devices and evaluated the usefulness of this approach.

Figure 1 NIHSS scores before and after treatment.

Patients

From May 1998 to July 2004, we treated 15 patients (13 men and two women, mean age of 67.3 years) with acute athero-sclerotic cervical carotid artery occlusion who had been transferred within four hours of onset and who showed neuro-logical symptoms (NIH stroke scale score 4-28). Patients with embolic carotid occlusion were excluded.

Diagnosis and Methods

Immediately after transfer to our hospital, we performed the following examinations routinely to assess indications of revascularization for hyperacute carotid artery occlusion: history taking, neurological findings, laboratory chemistry and complete blood count data, chest radiography, and ECG. Cases with early ischemic CT signs and bleeding demonstrated by brain CT were excluded. Subsequent urgent MRI with T1-weighted imaging, T2-weighted imaging, Flair, diffusion weighted imaging (DWI), perfusion weighted imaging (PWI), and MR angiography (MRA) were performed if possible.

Revascularization was accomplished for the patients with hyperacute carotid artery occlusion who had no early ischemic signs by CT or had DWI/PWI mismatch by MRI. Treatment modality included local intraarterial fibrinolysis (LIF), percutaneous transluminal angioplasty (PTA), and carotid artery stenting (CAS) using the parallel wire technique and distal protection technique, if required. In these cases, pre-and postoperative NIHSS score, presence of tandem occlusive lesion or contra-lateral occlusion, and their consequences were evaluated.

Figure 2 Case 8. Illustrative case. Admission MRI diffusion image demonstrating posterior watershed small HIA (left). Perfusion image demonstrating right-hemispheric massive low perfusion (middle). MRA demonstrating right-IC occlusion and rt-M1 distal occlusion due to distal embolus (right).

Figure 3 Case 8. Admission angiogram demonstrating acute right cervical ICA occlusion (left). The microcatheter was passed through and demonstrated the distal end of the lesion (middle). PTA was performed with a protective balloon.

Figure 4 Post-PTA angiogram demonstrating M1 distal embolus (left). Right M1 distal embolus was recanalized by fibrinolysis (middle). Angiogram demonstrating cervical ICA recanalization (right).

Figure 5 Case 7. Illustrative case. Admission MRI diffusion image demonstrating anterior and posterior watershed multiple high-intensity areas (upper). MRA demonstrating left ICA occlusion (lower).

First, penetration using a guidewire for complete occlusion was attempted and the distal side of the occlusion was confirmed with a microcatheter by injection of a small amount of contrast medium. In cases with limited occlusion without any clotting within the distal cervical carotid artery, revascularization and stenting were performed with the distal balloon protection method.

The distal protection balloon was navigated to the internal carotid artery along the microguidewire (parallel wire technique). In the cases in which the clot was observed in the internal carotid artery distal to the plaque, the clot was aspirated or washed out to the external carotid artery, with distal balloon protection, before stenting. In eight cases with distal intracranial thrombi, additional LIF or PTA was performed immediately after treatment of the carotid lesion.

Results

Revascularization was accomplished in 15 patients transferred to our hospital within four hours of onset, as shown in table 1. MRI was

performed in 12 cases and DWI/PWI mismatch was found in 11 of these cases. Treatment procedures were as follows: three patients were treated with LIF+PTA, five with PTA+CAS, six with LIF+PTA+CAS, and one with PTA only. An additional distal protection technique was performed in seven of these patients and an additional parallel wire technique was performed in one patient.

Successful recanalization (defined as $\geq 50\%$ recanalization of the carotid artery) was obtained in 14 of the 15 patients. There were eleven patients in whom the localized clot formation was observed in the internal carotid artery distal to the plaque. There were four patients in whom diffuse clot formation was observed in the distal carotid artery. There were no complications of embolic occlusion of the distal intracranial arteries due to endovascular procedures. Eight of the 15 patients had good outcome (GOS four or five), while the remaining seven had unchanging or poor outcome with remaining severe neurological symptoms (GOS 1-3). None of the patients died. Nine patients had intracranial tandem arterial occlusion, and eight of these patients underwent additional LIF/PTA resulting in successful recanalization of the distal occlusive lesion. Pre-operative NIHSS score (10.3 ± 7.4) in the good outcome group was significantly lower than that (21.3 ± 5.4) in the poor outcome group. There were no significant differences in post-operative NIHSS score (outcome) between patients with tandem occlusive lesions or contralateral lesions (table 1).

Duration

The mean duration from the onset to the end of treatment was 4.8 hours. The mean duration in the good outcome group was 4.4 hours, while that in the poor outcome group was 5.2 hours (n.s.).

Tandem Lesion

Tandem occlusive lesion due to the distal intracranial thrombi was observed in eight patients in preoperative MRI imaging and intraoperative angiogram. The tandem occlusive lesion in all cases with good outcome was located in the distal site of M1. On the other hand, the tandem lesions in the poor outcome group were located in the ICB in two cases, M2 in two cases, ICB and M2 in one case, M1 and A3 in one case.

Contralateral Lesion

There was no significant relationship between the presence of contralateral lesions and outcome.

Preoperative NIHSS Score

The mean preoperative NIHSS score of the 15 patients was 15.4 ± 7.4 . The mean NIHSS score of the cases in the good outcome group was 10.3 ± 7.4 , which was significantly lower than that in the poor outcome group (21.3 ± 5.4) (figure 1). The mean post operative NIHSS score was 0.8 ± 1.0 in good outcome group, and 14.0 ± 4.4 in the poor outcome group.

Case Presentation: Case 8

A 51-year-old woman who had undergone PTA in the left-superficial femoral artery three years previously experienced frequent right amaurosis fugax for the last year. She was brought to the hospital by ambulance because she had amaurosis fugax since waking up in the morning followed by a feeling of left hemiparesis.

Physical examination on admission showed left haemiparesis and an NIHSS score of four. CT of the brain did not show distinguishing findings and then MRI was performed. A small high intensity area in the cortical watershed area was demonstrated by DWI/MRI. Right-internal carotid artery (ICA) occlusion and right-proximal middle cerebral artery (MCA) occlusion were suspected based on MRA findings. Time to peak by PWI/MRI was prolonged more than double than that in the contralateral site indicating decreased blood flow (figure 2). Right carotid artery occlusion was demonstrated by carotid ultrasonography with lower echoic plaque.

Endovascular surgery: Case 8

After the guiding catheter was placed in the right cervical carotid artery, the medial wall of the stenosis was penetrated with a microguidewire. Then, the microcatheter was moved sufficiently distal to the ICA to confirm that the catheter was deployed in the true lumen. Leaving the microguidewire in place, the pro-

Table 1 Summary of cases.

Case	Age/ Sex	duration	side	Pre NIHSS	distal Embolus	Contralateral IC stenosis	Collateral flow	Intervention	Patency	Post NIHSS	onset to Angio
1	75/M	5,5	rt	4	M2	70%	Acom	LIF, PTA	50%	1	2,5
2	75/M	4	lt	7	No	100%	-	PTA, STENT	100%	0	2
3	65/M	4	lt	25	No	0%	Oph A	LIF, STENT	80%	0	2
4	71/M	5	rt	18	M3	60%	Acom	LIF, PTA, STENT	100%	1	2,5
5	70/W	4	lt	7	No	50%	Acom	LIF, PTA, STENT	100%	0	1,5
6	67/M	4	lt	8	No	90%	PCA	PTA, STENT	100%	3	3
7	69/M	4	lt	9	No	0%	Acom	PTA, STENT	100%	1	3
8	51/F	5	rt	4	M1	0%	ACA	LIF, PTA, STENT	100%	0	2,5
9	74/M	5,5	rt	18	No	?	Acom	PTA, STENT	20%	18	3
10	66/M	7,5	lt	28	ICB & M2	80%	Acom A1 occl	LIF, PTA, STENT	100%	13	3
11	72/M	6,5	rt	27	ICB	90%	Pcom	PTA	80%	19	3
12	60/M	4	rt	16	M2	90%	Pcom	LIF, PTA	100%	14	2
13	55/M	4	lt	26	M2	100%	-	LIF, PTA, STENT	100%	16	1,5
14	67/M	3	rt	16	M1 & A3	50%	Oph A	PTA, STENT	100%	6	2
15	73/M	6	rt	18	ICB	0%	Oph A	PTA, STENT	100%	12	4

Duration: time from the onset to the end of treatment.
Pre-NIHSS: NIHSS scores before treatment. Post-NIHSS: NIHSS scores after treatment.

Figure 6 Case 7. Admission angiogram demonstrating acute left cervical ICA occlusion (left). Left ICA injection from microcatheter demonstrating distal ICA (middle). PTA was performed with a protective balloon (right).

protective balloon was inserted along to the microguidewire distal to the ICA (parallel wire technique) (figure 3).

The stent was applied immediate after predilatation, in which the protective balloon was inflated to insulate the ICA. Consequently, the tandem occlusive lesion in the distal M1 segment was reanalyzed successfully by fibrinolysis (figure 4).

Case presentation: Case 7

A 69-year-old man who had undergone radiation therapy for a cervical tumor 25 years previously experienced numbness in his right arm for one month. He complained of faintness from the morning followed by difficulty in waking with paralysis of the legs. He was referred to our hospital by a local clinic. Physical examination on admission showed rt-hemiparesis, aphasia, and an NIHSS score of nine. CT of the brain did not show distinguishing findings. Multiple small high-intensity areas (HIA) in the left-parietal cortex and cerebral cortex were demonstrated by DWI/MRI. Left-ICA occlusion was indicated by MRA and carotid ultrasonography (figure 5).

Endovascular surgery: Case 7

The guiding catheter was deployed in the left cervical carotid artery by the trans-femoral approach.

The microcatheter and microguidewire were moved distal to the carotid artery, confirming backflow, to ascertain that the microcatheter was placed in the true lumen by infusion of a small quantity contrast medium (figure 6).

The occluded lumen was inflated with a small PTA balloon catheter; (3 mm in diameter, 40 mm in length) because of difficulty in applying a protective balloon along with the microguidewire, and this allowed the protective balloon to be placed distal to the ICA. Following inflation of the protective balloon to insulate the ICA and suction of the clot distal to the plaque, a SMART stent; (8 mm in diameter, 40 mm in length) was put in place. After post-dilatation (7 mm in diameter, 20 mm in length), ICA was restored.

Postoperative digital subtraction angiography showed satisfactory dilation without peripheral thrombi. Immediately after this, the patient's aphasia and paralysis improved (figure 7).

Figure 7 Angiogram demonstrating complete recanalization of left cervical ICA (left). Post-stenting angiogram demonstrating normal intracranial circulation (right).

Conclusions - Discussion

The natural history of ICA occlusion has been reported previously: 2-12% of cases show good prognosis, profound neu-rological deficits remain in 40-69%, and 16-55% die². The prognosis of surgery for ICA occlusion with neurological deficits is poor and favorable results were reported only in selected mild cases without disturbance of consciousness, hemiplegia, or aphasia². Traditionally, such patients with complication of severe neurological deficits or disturbance of consciousness are not considered eligible even for urgent endovascular treatment. We previously reported the effective combined treatment of emergency local fibrinolysis followed by PTA or endarterectomy in cases with acute carotid occlusion³. We showed the potential of this treatment with additional procedures such as PTA or endarterectomy. In recent days, we have effective devices of protective balloons and carotid stents available to this treatment. In the present cases, all patients showed recovery or no change. Eight cases (53%) showed GOS of 4 or 5.

Tandem Lesion

The outcome was significantly better in cases with lower NIHSS score (less than 16 points) at onset. McCormick et Al. reported favorable results only in selected mild cases¹. However, there was no discussion regarding tandem occlusive lesions in their article. MCA embolus was described as a poor prognostic factor in previous reports of CEA, embolectomy².

The present study indicated that additional PTA/LIF yielded better results in the tandem occlusive lesion distal to M2. Tandem internal carotid bifurcation or M1 lesions have a poorer prognosis than tandem occlusive lesions distal to M2 because of the lack of contralateral blood flow.

Contralateral Lesion

Previous studies of CEA indicated that the incidences of cerebral infarction or death were higher in patients with occlusion or severe stenosis of the contralateral ICA⁴. Although in cases with contralateral lesions, insufficient collateral blood supply was considered to cause poorer outcome, in our cases there was no sig-

nificant association between contralateral lesion and outcome.

MRI

Recent studies have indicated that revascularization of acute carotid artery occlusion is indicated in cases with DWI/PWI mismatch^{6,7,8}. Based on these recent reports, we performed revascularization in cases with DWI/PWI mismatch.

The present study indicated that revascularization of acute carotid occlusion may be applied in some cases with DWI/PWI mismatch, even in those complicated with tandem or contralateral lesions, which were considered poor prognostic factors.

Procedure

Prompt penetration with the guidewire is the key to success of endovascular recanalization, while Wang et Al. reported no complications of recanalization with a guidewire, including peripheral thrombi, vascular penetration, or vascular dissection, in six cases with complete carotid occlusion⁸. In all 15 of our cases, the occlusion was successfully penetrated by the guidewire allowing sequent procedures. As plaque in the cervical internal carotid artery is

located mostly in posterior or lateral sites, it may be necessary to direct the microguidewire toward the anterior or medial site to pass the site of occlusion in most cases. In this direction, the microguidewire must be advanced prudently with free force and rotation within the true lumen to avoid vascular dissection. The sequent parallel wire technique and distal protection technique are highly beneficial, as described above. The protective balloon is efficacious for prevention of peripheral thrombus formation. However, it has the disadvantage in that it must be passed into the occluded lesion; Parodi's proximal protection system (Parodi Anti-Embolism System DAESX) may be a superior alternative^{9,10}.

Endovascular surgery is beneficial in that it permits prompt treatment of occluded lesions and tandem lesions with sequent angiography as compared to general surgery. Patients with acute carotid occlusion with relatively mild neurological deficits (NIHSS score <16) and sufficient collateral circulation could be good candidates for this advanced treatment, particularly in cases with DWI/PWI mismatch. In addition, various advanced techniques or devices, such as the parallel wire technique or distal protection technique, should be used fully.

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